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| 2. Patent application number *(The Patent Office will fill in this part)* | 07 DEC 2000 | **0029856.2** |
| 3. Full name, address and postcode of the or of each applicant *(underline all surnames)* | SONY UNITED KINGDOM LIMITED<br>THE HEIGHTS<br>BROOKLANDS<br>WEYBRIDGE<br>SURREY<br>KT13 0XW | |
| Patents ADP number *(if you know it)* | | 6522700001 |
| If the applicant is a corporate body, give the country/state of its incorporation | UNITED KINGDOM | |
| 4. Title of the invention | DATA DETECTING AND EMBEDDING APPARATUS | |
| 5. Name of your agent *(if you have one)* | **D YOUNG & CO** | |
| "Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode) | **21 NEW FETTER LANE<br>LONDON<br>EC4A 1DA** | |
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Signature D Young & Co    Date

**D YOUNG & CO**    6 Dec 2000
Agents for the Applicants

12. Name and daytime telephone number of person to contact in the United Kingdom    Dr Jonathan DeVile    023 80719500

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# DATA DETECTING AND EMBEDDING APPARATUS

## Field of Invention

The present invention relates to methods and apparatus for detecting and recovering data embedded in information material.

Information material as used herein refers to and includes one or more of video material, audio material and data material. Video material in this context may be still images or moving images.

## Background of Invention

Steganography is a technical field relating to the embedding of data into material such as video material, audio material and data material in such a way that the data is imperceptible in the material.

Watermarks are data embedded in material such as video material, audio material and data material. A watermark may be imperceptible or perceptible in the material.

A watermark may be used for various purposes. It is known to use watermarks for the purpose of protecting the material against, or trace, infringement of the intellectual property rights of the owner(s) of the material. For example a watermark may identify the owner of the material.

Watermarks may be "robust" in that they are difficult to remove from the material. Robust watermarks are useful to trace the provenance of material which is processed in some way either in an attempt to remove the mark or to effect legitimate processing such as video editing or compression for storage and/or transmission. Watermarks may be "fragile" in that they are easily damaged by processing which is useful to detect attempts to remove the mark or process the material.

Visible watermarks are useful to allow, for example, a customer to view an image via, for example, the Internet to determine whether they wish to buy it but without allowing the customer access to the unmarked image they would buy. The watermark degrades the image and the mark is preferably not removable by the customer. Visible watermarks are also used to determine the provenance of the material into which they are embedded.

In US patent 5,930,369 (Cox et al) it has been proposed to embed data into material such as images to form a watermark by converting the material into the transform domain and adding the data to the image in the transform domain. For the example of images and the Discrete Wavelet Transform of these images, the data to be embedded can be combined with the wavelet coefficients of one of a plurality of sub-bands which are formed in the transform domain. Generally, the data to be embedded is arranged to modulate a predetermined data sequence such as a Pseudo Random Bit Sequence (PRBS). For example, each bit of the data to be embedded is arranged to modulate a copy of the PRBS, and this copy is then added, for example into one of the sub-bands of the image in the transform domain. The image is then converted back to the spatial domain.

If it is desired to detect and recover the embedded data from the image, the image is converted back to the transform domain and the embedded data is recovered from the sub-band in the transform domain by correlating the transform coefficients in the sub-band with the Pseudo Random Bit Sequence which is known to the detecting apparatus. The data is detected from the result of the correlation.

Generally, it is desirable to reduce to a minimum any perceivable effect that the embedded data may have on the information material such as images. However it is also desirable to increase the likelihood of correctly recovering the embedded data from the information material, in spite of errors which may be introduced as a result of any processing which may be performed on the material.

**Summary of Invention**

According to the present invention there is provided an apparatus for embedding data in information material, the data being a plurality of data items each having a different relative importance, the apparatus comprising an encoding processor operable to encode each of the data items, a combining processor operable to combine the encoded data items with the information material, wherein the information material provides a limited data embedding capacity, and each of the data items are encoded and embedded to the effect that a proportion of the limited data embedding capacity is allocated to the data items in accordance with the relative importance.

Embedding data in information material such as images can present a compromise between increasing the likelihood of recovering the embedded data, requiring a higher strength with which the data is embedded, and reducing the likelihood of the embedded data causing a visually perceivable effect to the image. This compromise in addition sets a limit on the amount of data which can be embedded in the information material, because too much embedded data may cause a perceivable degradation on the material and reduce a likelihood of correctly recovering the data. Furthermore, a limit on the amount of data which can be embedded in the information material may exist as a result of a physical limit on the bandwidth of the information material itself. For the example of information material such as images which are typically divided into frames of image data, there will be a physical limit on the amount of data in the image frame, and therefore a corresponding limit on the amount of data which can be embedded. This is particularly true if the data items are embedded in the image by modulating a PRBS and adding the modulated PRBS to the image material in either a transform domain representation of the image or a spatial domain representation of the image. This is because modulating the PRBS with the data to be embedded generates a spread spectrum signal representing a significantly increased amount of data to be added to the information material.

The data to be embedded into the information material may comprise a plurality of data items. Typically, some data items may be more important than other data items. For the example in which the information material is video images, and the data items to be embedded in the video images comprise meta data items describing the content or some attributes of the images, the owner of the image may represent the most important meta data. Other meta data such as the location at which the video images were generated or a transcript of the dialogue, may represent less important meta data.

Embodiments of the present invention address a technical problem of embedding data items of different relative importance within a limited data embedding capacity of the information material. To this end, the encoding processor and the embedding processor are operable to adjust an amount of coding and/or adjust the embedding of the data to the effect that the more important data items are afforded greater protection within the limited embedding data capacity, providing a greater

likelihood of correctly recovering the data. The more important data items may therefore acquire a greater proportion of the available capacity than less important data items.

In preferred embodiments, the encoding processor is operable to encode the data items in accordance with at least one error correction code, the encoded data items including redundant data introduced by the error correction code, wherein the combining processor is operable in combination with the encoding processor to allocate an amount of the limited bandwidth and to generate an amount of the redundant data included in the encoded data fields in accordance with the relative importance. According to this embodiment the relative allocation of the limited embedding capacity is made in accordance with importance, by increasing the amount of redundancy afforded to the more important data. This can be effected, for example, by providing a separate error correction code to each item of data, the power of the allocated code being arranged in accordance with the relative importance of the data items concerned. Correspondingly the more powerful code will generate a greater amount of redundant data, and therefore occupy more of the limited embedding capacity. Accordingly, the error correction codes are also selected to the effect that the total quantity of data from the encoded data items can be accommodated within the limited data embedding capacity.

In an alternative embodiment the combining processor may be operable to embed the data items in accordance with an application strength, the application strength being applied in proportion with the relative importance of the data items. As such, the more important data will be more likely to be recovered albeit at the expense of an increased likelihood of any perceptual effects on the information material. The encoding processor may modulate a predetermined data sequence such as a PRBS in order to form an encoded version of the data which is then embedded in accordance with the proportioned application strength. Accordingly any visually perceivable effects of the embedded data may be reduced.

In an alternative embodiment, the encoding processor may operate to generate a plurality of predetermined data sequences and to encode the data items by modulating a copy of the predetermined data sequences with data symbols of the data items, and to combine the modulated predetermined data sequences with the

information material, wherein predetermined data sequences are allocated to the effect that a greater amount of spreading is provided to the more important data items, thus providing an allocation of the embedding capacity.

Embedding the data items by generating predetermined data sequences, such as PRBSs, modulating the predetermined data sequences with the data to be embedded and combining the modulated data sequences with the information material has a effect of generating a spread spectrum signal for the embedded data. As such, generating a plurality of such sequences for bearing the data items provides a facility for allocating more capacity for embedding data to the more important data items. This can be effected by either allocating a greater number of data sequences to the more important data or allocating longer data sequences to the more important data items. This is because a detector for recovering the embedded data can recover the data by correlating the data embedded information material with a re-generated version of the corresponding predetermined data sequence to recover the data. It is a property of predetermined data sequences such as PRBSs that the other PRBSs used to embed other data items will appear as noise to the PRBS of the data being detected.

Although embodiments of the invention find application in detecting and recovering data from any information material, a particular application of the invention is in detecting and recovering data embedded in video image or audio signals.

Various further aspects and features of the present invention are defined in the appended claims.

**Brief Description of the Drawings**

Figure 1 is a schematic block diagram of a watermarking system;

Figure 2 is a schematic block diagram of a watermark embedder appearing in Figure 1;

Figure 3 is a schematic block diagram of an error correction encoder forming part of the watermark embedder shown in Figure 2;

Figure 4 is a schematic block diagram of a combiner forming part of the watermark embedder shown in Figure 2;

Figure 5 provides an illustrative representation of a transform domain image with which data is combined;

Figure 6 is a schematic block diagram of a watermark decoder appearing in Figure 1;

Figure 7 is a schematic block diagram of an error correction decoder forming part of the watermark decoder shown in Figure 6;

Figure 8 is a schematic representation of a modulator forming part of the combiner shown in Figure 2, in accordance with a further embodiment of the present invention;

Figure 9 provides a schematic representation of the operation of the correlator forming part of the watermark decoder shown in Figure 6, according the further embodiment of the invention; and

## Description of Preferred Embodiments

An example embodiment of the present invention will be described with reference to a watermarking system in which data is embedded into a video image. Any type of data can be embedded into the image. However, advantageously the data embedded into the image may be meta data which describes the image or identifies some attributes of the content of the image itself. One example of meta data is the Unique Material Identifier (UMID). A proposed structure for the UMID is disclosed in SMPTE Journal March 2000.

## Watermarking System

Figure 1 illustrates a watermarking system, generally 10, for embedding a watermark into a video image 115, and recovering and removing a watermark from the watermarked video image 125. The watermarking system 10 in Figure 1 comprises an image processor 100 for embedding the watermark into the video image, and a decoding image processor 102 for detecting and recovering the watermark, and for removing or 'washing' the watermark from the video image.

The image processor 100 for embedding the watermark into the video image comprises a strength adapter 180, and a watermark embedder 120. The watermark embedder 120 is arranged to embed the watermark into the video image 115, produced from the source 110, to form a watermarked image 125. The watermark to be embedded into the video image is formed from data 175 representing, for this example embodiment various items of meta data. Generally, the meta data items identify the

content of the video image. It will be appreciated that various types of meta data which identify the content or other attributes of the image can be used to form the watermark. In preferred embodiments the watermark embedder 120 embeds the meta data items into the video image 115 in accordance with a particular application strength 185 from the strength adapter 180. The strength adapter 180 determines the magnitude of the watermark in relation to the video image 115, the application strength being determined such that the watermark may be recovered whilst minimising any effects which may be perceivable to a viewer of the watermarked image 125. After embedding the watermark, the image may be transmitted, stored or further processed in some way, such as for example, compression encoding the image. This subsequent processing and transmitting is represented generally in Figure 1 as line 122.

In Figure 1 the decoding image processor 102 for detecting and removing the watermark is shown as comprising a watermark decoder 140, a data store 150 and a watermark washer 130 which removes the watermark from the watermarked image 125.

The watermark decoder 140 detects the watermark from the watermarked video image and in the present example embodiment, generates a restored version of the meta data items 145 from the watermarked image 125. The watermark washer 130 generates a restored image 135, by removing as far as possible the watermark from the watermarked image 125. In some embodiments, the watermark washer 130 is operable to remove the watermark from the image substantially without leaving a trace. The restored image 135 may then be stored in a store 150, transmitted or routed for further processing.

**The Watermark Embedder**

The watermark embedder will now be described in more detail with reference to Figure 2, where parts also appearing in Figure 1 have the same numerical references. In Figure 2 the watermark embedder 120 comprises a pseudo-random sequence generator 220, an error correction encoder 200, a wavelet transformer 210, an inverse wavelet transformer 250, a modulator 230 and a combiner 240.

The error correction encoder 200 receives the meta data items 175 and generates error correction encoded data items. The operation of the encoder 200 will be explained in more detail shortly.

As shown in Figure 2 the error correction encoded meta data items 205 are received at a first input to the modulator 230. The pseudo-random sequence generator 220 outputs a PRBS 225 which is received at a second input to the modulator 230. The modulator 230 is operable to modulate each copy of a PRBS, generated by the pseudo-random sequence generator 220, with each bit of the error correction encoded meta data items. In preferred embodiments the data is modulated by representing the values of each bit of the PRBS in bipolar form ('1' as +1, and '0' as –1) and then reversing the polarity of each bit of the PRBS, if the corresponding bit of the encoded UMID is a '0' and not reversing the polarity if the corresponding bit is a '1'. The modulated PRBS is then received at a first input of the combiner 240. The combiner 240 receives at a second input the image in which the PRBS modulated data is to be embedded. However the data is combined with the image in the transform domain.

The use of a pseudo-random sequence 225 to generate the spread spectrum signal representing the watermark data allows a reduction to be made in the strength of the data to be embedded in the image. By correlating the data in the transform domain image to which the modulated PRBS has been added, a correlation output signal is produced with a so called correlation coding gain which allows the modulated data bit to be detected and determined. As such, the strength of the data added to the image can be reduced, thereby reducing any perceivable effect on the spatial domain image. The use of a spread spectrum signal also provides an inherent improvement in robustness of the image because the data is spread across a larger number of transform domain data symbols.

As shown in Figure 2, the wavelet transformer 210 receives the video image 115 from the source 110 and outputs a wavelet image 215 to the combiner 240. The image is thus converted from the spatial to the transform domain. The combiner 240 is operable to add the PRBS modulated data to the image in the transform domain, in accordance with the application strength, provided by the strength adapter 180. The watermarked wavelet image 245 is then transformed into the spatial domain by the

inverse wavelet transformer 250 to produce the watermarked image 125. The operation of the combiner 240 will be explained in more detail shortly.

The skilled person will be acquainted with the wavelet transform and variants. A more detailed description of the wavelet transform is provided in for example "A Really Friendly Guide to Wavelets" by C Valens, 1999 (c.valens@mindless.com).

Although in the example embodiment of the present invention the data is embedded in the image in the wavelet transform domain, it will be appreciated that the present invention is not limited to the wavelet transform and could be added to the image using any transform such the Discrete Cosine Transform or the Fourier Transform. Furthermore the data could be combined with the image in the spatial domain without forming a transform of the image.

**Encoder**

The error correction encoder 200 will now be explained in more detail. In Figure 3 an example of an error correction encoder is shown where parts also appearing in Figures 1 and 2 bear identical numerical references. As shown in Figure 3 the data to be encoded and embedded in the video images is received via parallel conductors 175.1, 175.2, 175.3 each of which conveys meta data of a different type.

The example embodiment will be illustrated with reference to three types of meta data. The three types of meta data are provided on the three parallel conductors 175.1, 175.2, 175.3. As will be appreciated there are various types of meta data which are generally associated or describe the content of the video image signals. The meta data may be on one channel a UMID or on other channels a location, time, identification of the owner, transcripts of the dialogue conducted as represented in the video image or various other types of meta data.

As shown in Figure 3, the three types of meta data are received by a control processor C_P. The three types of meta data which are to be encoded and embedded in the video image are on the first channel 175.1 the type of program content of the video images, for example current affairs, comedy, sport or light entertainment, on the second channel 175.2, a transcript of the discussion between people contained in the video images, such as an interviewer and interviewees and on the third channel 175.3 the camera settings used in capturing the video images.

For the example embodiment illustrated in Figure 3 the three meta data types are considered to be presented in an increasing order of importance as going from left to right across the control processor C_P. The control processor C_P may also receive control information via a control channel C_CHN which may indicate an amount of data embedding capacity available to the three meta data types. Furthermore, in alternative embodiments the control channel C_CHN may convey control information indicative of a relative importance of the meta data received on the respective input channels 175.1, 175.2, 175.3. Alternatively, as with the present illustration, the relative importance may be predetermined, that is to say, the order of importance of the meta data types may be predetermined and therefore fed to the control processor C_P on the respective parallel channels in an increasing order of importance.

The control processor C_P determines a relative allocation of the embedded data capacity to the three meta data types, in accordance with their relative importance. The protection afforded to each of these types is allocated in accordance with this relative importance. As a result, the program type meta data received on the first channel 175.1 is fed to a first encoder ENC.1 via a connecting channel 202.1. The encoder ENC.1 operates to encode the first type of meta data in accordance with an error correction code either selected by the control processor C_P and indicated from control signals received from a control channel CNT.1 or an error correction code which is pre-allocated. For example, the error correction code could be a block code providing approximately a one third coding rate, that is a ratio of source data to encoded data is 1:3 (rate 1/3). The second meta data type is fed to a second encoder ENC.2 via a second connecting channel 202.2.

As with the first encoder the second type of data fed to the second encoder ENC.2 is error correction encoded in accordance with either a predetermined error correction code or a correction code identified by control information received on the control channel CNT.2. Accordingly, the relatively reduced importance of the second type of meta data is used to pre-allocate or select an error correction code applied by the second encoder ENC.2 which is less powerful than that applied by the first encoder ENC.1. As such, the amount of redundant data added to the meta data items in the encoded form will be reduced in comparison to the first encoder ENC.1. For example, the second encoder ENC.2 may operate in accordance with a half rate code.

For the third type of meta data received on the third channel 175.3, the control processor for the present example does not apply any coding to this data so that the meta data items from the third type are fed via a connecting channel 202.3 to a multiplexing unit MUX. The multiplexing unit MUX combines the data items from the third meta data type with the encoded data items received from the first and second encoder ENC.1, ENC.2 and forms a multiplexed data stream which is fed on the connecting channels 205 to the combiner 230 as shown in Figure 2.

It will be appreciated that the present invention is not limited to any particular error correction encoding scheme, so that for example a Bose-Chaudhuri-Hocquenghem (BCH) code, Reed-Solomon codes or convolutional codes could be used to encode the UMIDs. For the case of convolutional codes, the data could be encoded using the same convolutional code and punctured in order to reflect the relative importance of the data.

As indicated above in alternative embodiments the relative importance of the meta data received on the parallel channels 175 may be unknown to the encoder 200. However in this case the relative importance of the meta data types will be fed to the controller processor C_P via the control channel C_CHN. This relative importance may be input by a user or may be pre-selected in accordance with a predetermined menu option. Similarly the amount of data embedding capacity available to the control processor C_P maybe unknown or may vary dynamically with the effect that the control processor C_P is operable in alternative embodiments to determine the amount of encoding applied to the respective meta data items in accordance with their relative importance such that the data items can be encoded within the limited embedding capacity available. However, with this alternative embodiment, it may be necessary to embed control data indicative of the error correction code used to encode each of the meta data items and also an indication of the position of each of the encoded meta data items for each meta data type within the encoded data stream.

## Combiner

The operation of the combiner 240 will now be explained in more detail. The combiner 240 receives the wavelet image 215 from the wavelet transformer 210, and

the modulated PRBS from the modulator 230 and the application strength 185 from the strength adapter 180. The combiner 240 embeds the watermark 235 onto the wavelet image 215, by adding, for each bit of the modulated PRBS a factor $\alpha$ scaled by ±1, in dependence upon the value of the bit. Selected parts of the wavelet image 215 are used to embed the watermark 235. Each pixel of the predetermined region of the wavelet image 215 is encoded according to the following equation:

$$X_i' = X_i + \alpha_n W_i \qquad (1)$$

Where $X_i$ is the i-th wavelet coefficient, $\alpha_n$ is the strength for the $n$-th PRBS and $W_i$ is the $i$-th bit of the PRBS to be embedded in bipolar form.

An example of the combiner and the operation of the combiner will now be described with reference to Figures 4 and 5. In Figure 4 the combiner 240 is shown to receive the transform domain image from the connecting channel 215 which provides the transform domain image to a frame store 236. The frame store 236 is arranged to store a frame of transform domain data. The combiner 240 is also arranged to receive the spread spectrum encoded and error correction encoded data after it has been spread using the PRBS (modulated PRBS data). For this example embodiment an amount of data in this error correction and spread spectrum encoded form is to be embedded in the frame of image data within the frame store 236. A limit on the amount of data which can be embedded is therefore set in accordance with the amount of data in the image frame, and the nature of the image to the extent that the image can withstand the effects of the embedded data. The encoded data forms a total amount of data which is to be embedded into each frame of image data within this capacity limit. To this end, the frame store stores a frame of data representing the image in the wavelet transform domain. The data to be embedded is received at a combining processor 237 which combines the data to be embedded into selected parts of the wavelet transform domain image stored in the frame store 236. The combiner 240 is also provided with a control processor 238 which is coupled to the combining processor 237. The control processor 238 receives the application strength from the strength adapter 180 and controls the combining of the modulated PRBS data with the information material, in accordance with the application strength, as expressed by equation (1) above. The control processor 238 is also arranged to monitor the available data embedding

capacity, and then combine the modulated PRBSs with the information material in accordance with this available data embedding capacity. Signals representative of the available data embedding capacity may be communicated to other parts of the watermark embedder, such as, the control processor C_P of the error correction encoder shown in Figure 3, or the modulator 230.

In Figure 5 an illustrative representation of a first order wavelet transform is presented. This wavelet transform is representative of a frame of the image transformed into the wavelet domain and stored in the frame store 236. The wavelet transform image WT_IMG is shown to comprise four wavelet domains representative of sub-bands into which the image has been divided. The wavelets comprise a low horizontal, low vertical frequencies sub-band $lH_1lV_1$, the high horizontal, low vertical frequencies sub-band $hH_1lV_1$, the low horizontal, high vertical frequencies sub-band $lH_1hV_1$ and the high horizontal, high vertical frequencies sub-band $hH_1hV_1$.

In the example embodiment of the present invention, the data to be embedded is only written into the high horizontal, low vertical frequencies sub-band $hH_1lV_1$ and the low horizontal, high vertical frequencies sub-bands labelled $lH_1hV_1$.

By embedding the data in only the two sub-bands $hH_1lV_1$, $lH_1hV_1$, the likelihood of detecting the embedded data is improved whilst the effects that the embedded data will have on the resulting image are reduced. This is because the wavelet coefficients of the high horizontal, high vertical frequencies sub-bands $hH_1hV_1$ are more likely to disturbed, by for example compression encoding. Compression encoding processes such as JPEG (Joint Photographic Experts Group) operate to compression encode images by reducing the high frequency components of the image. Therefore, writing the data into this sub-band $hH_1hV_1$ would reduce the likelihood of being able to recover the embedded data. Conversely, data is also not written into the low vertical, low horizontal frequencies sub-band $lH_1lV_1$. This is because the human eye is more sensitive to the low frequency components of the image. Therefore, writing the data in the low vertical, low horizontal frequencies sub-band would have a more disturbing effect on the image. As a compromise the data is

added into the high horizontal, low vertical frequencies sub-band $hH_1lV_1$ and the low horizontal, high vertical frequencies sub-bands $lH_1hV_1$.

**Decoder**

The operation of the watermark decoder 140 in the decoding image processor of Figure 1, will now be explained in more detail, with reference to Figure 6, where parts also appearing in Figure 1, bear identical reference numerals. The watermark decoder 140 receives the watermarked image 125 and outputs a restored version of the UMID 145. The watermark decoder 140 comprises a wavelet transformer 310, a pseudo-random sequence generator 320, a correlator 330, and an error correction decoder 350.

The wavelet transformer 310 converts the watermarked image 125 into the transform domain so that the watermark data can be recovered. The wavelet coefficients to which the PRBS modulated data were added by the combiner 240 are then read from the two wavelet sub-bands $hH_1lV_1$, $lH_1hV_1$. These wavelet coefficients are then correlated with respect to the corresponding PRBS used in the watermark embedder. Generally, this correlation is expressed as equation (2), below, where $X_n$ is the $n$-th wavelet coefficient and $R_i$ is the $i$-th bit of the PRBS generated by the Pseudo Random Sequence Generator 320.

$$C_n = \sum_{i=1}^{s} X_{sn+i} R_i \qquad (2)$$

The relative sign of the result of the correlation $C_n$ then gives an indication of the value of the bit of the embed data in correspondence with the sign used to represent this bit in the watermark embedder. The data bits recovered in this way represent the error correction encoded data which is subsequently decoded by the error correction decoder 350 as will be explained shortly. Having recovered the data items, the watermark can be removed from the video image by the watermark washer 130, by performing the reverse of the operations performed by the embedder.

A diagram representing an example implementation of the error correction decoder 350 is shown in Figure 7 where parts also appearing in Figures 6 and 1 bear the same numerical references. Generally, it will be appreciated that the decoder shown in Figure 7 operates to perform a reverse of the encoding performed by the

encoder shown in Figure 3. Accordingly, the recovered embedded data stream from the correlator 330 is fed to a control processor C_P.D from the control channel 345. In accordance with the predetermined order and importance with which the three data types were encoded, the control processor C_P.D separates the encoded data items corresponding to each of the three meta data types and feeds these respectively to the connecting channels 347.1, 347.2, 347.3. The first, second and third encoded data items are then fed respectively to a first decoder DEC.1, a second decoder DEC.2 and for the third data items for the third meta data type the data is fed directly to an output processor OUT_P, because this was not encoded. The first and second decoders DEC.1, DEC.2 operate to decode the encoded data items using a decoding algorithm suitable for the error correction code applied by the first and second encoders ENC. 1, ENC.2 of the encoder 200 shown in Figure 3. The recovered data items are then fed to the output processor OUT_P and output on respective output channels 145.1, 145.2, 145.3.

For the example arrangement in which the encoding applied by the encoder 200 shown in Figure 3 is set dynamically by the control processor, the recovered data stream fed on connecting channel 345 will include control information providing an indication of the error correction code used for the respective first and second meta data items. Correspondingly the control information also provides an indication of where each of the encoded data items are positioned within the recovered data stream. According to this embodiment therefore the control processor C_P.D provides control signals on control channels CNT_D.1, CNT_D.2 to indicate to the first and second decoders which decoding process to use. The decoding process may be adapted, or a different decoding process may be used in accordance with the error correction code used by the encoders ENC.1, ENC.2 to encode the data items.

**Second Embodiment**

In an alternative embodiment, the different meta data types may be embedded in accordance with their relative importance using different PRBSs. An example of an implementation of the combiner 230 which operates in order to embed the data in accordance with the relative importance of each meta data type is shown in Figure 8. In Figure 8 three parallel connecting channels 225.1, 225.2, 225.3 from the pseudo

random sequence generator 220 are shown to generate respectively first, second and third PRBSs. The data from the encoder is received via the connecting channel 205 at a de-multiplexing processor 207. For this example illustration it is assumed that the three meta data types are fed from the error correction encoder generator 200 in a multiplexed form so that the de-multiplexer 207 operates to separate the data items corresponding to the three meta data types. For the present example embodiment it is assumed that the error control encoder 200 is applying the same error correction code to each of the three data types, although it will be appreciated that in alternative embodiments, different codes could be used as for the first embodiment.

The encoded data items for each of the three data types are fed separately to respective correlators C1, C2, C3. The relative importance of the three meta data types is assumed to increase going from left to right for the correlators C1, C2, C3. Each correlator receives the respective PRBS and modulates the PRBS in accordance with the data symbols of the encoded data items.

As illustrated in Figure 8 the most important meta data items are provided with the longest PRBS P_1 of 600-bits so that the data bits of the first meta data type are spread by the greatest amount. Correspondingly, for the second meta data type the next longest PRBS P_2 of 400-bits is provided so that the symbols of the second meta data type are spread by a correspondingly reduced amount. For the least important data type only, a PRBS P_3 of only 200-bits is used providing the smallest amount of spreading. The modulated PRBSs from each of the three combiners C1, C2, C3 are then combined together by an adder ADD.

By combining the modulated PRBSs together, a composite signal CS is produced which effectively provides a spread spectrum signal for each of the three meta data types. The composite signal is then combined with the image by the combiner 240 shown in Figure 2 as already explained.

The three meta data types may be recovered from the image by the correlator 330 in the decoder 140 as already explained with reference to the Figure 6. However in order to detect and separate the three meta data types, the correlator of Figure 6 is adapted to the effect that the three PRBSs P_1, P_2, P_3 are correlated separately with the transform domain image in order to recover the first, second and third meta data types respectively. This is represented in Figure 9 where each of the three PRBSs P_1,

P_2, P_3 are correlated with the image data symbols WI to which the spread spectrum encoded data has been added, to extract the three types of meta data item. The correlation is represented schematically by the multiplier C_MT and an adder C_ADD. For the case of the first most important data, the longest PRBS P_1 will produce a higher correlation result than the second or third PRBSs, thereby increasing the likelihood of detecting the first meta data type, with respect to the second and third meta data types. Correspondingly, the second meta data type will be more likely to be recovered correctly than the third meta data type.

It will be appreciated that the spread spectrum encoding of the data to be embedded can be considered to represent a limitation on the amount of data which can be embedded in this way. This is because the other modulated PRBSs represent noise to a wanted PRBS. Provided the noise is not so high as to mask a correlation output result when the correct PRBS aligns with the PRBS used to embed the data, the data can be recovered. Therefore a maximum number of PRBSs which can be added together but from which the embedded data can still be recovered from the correlation of the wanted PRBS with the embedded data can be considered to represent a limited capacity for embedding data. Accordingly, the length or number of PRBSs allocated for each of the respective data types can be determined in accordance with their relative importance. In alternative embodiments, the data may also be encoded by the error correction encoder to provide a different amount of redundancy per data type which are then combined with separate PRBSs in accordance with importance.

**Other Embodiments**

In a further embodiment, the application strength with which the PRBSs are added to the wavelet coefficients can be adapted in accordance with relative importance. As such more important data can be given a higher application strength.

In an alternative embodiment, the control processor 238 within the combiner 240 may be arranged to form a plurality of data items into an order of relative importance, and to embed the items selectively in accordance with this order within the limited data embedding capacity provided by the information material. Thus, if the embedding capacity is reached then the data items of lower importance after the more important data items have been embedded within the embedding capacity are queued.

As already explained the data items of lower importance are therefore queued by the combining processor until sufficient embedding capacity becomes available for these data items to be embedded. The data embedding capacity may vary dynamically either as a result of a characteristic of the information material, or because the demand to embed more important data items reduces, thereby making more capacity available for the more important data items. The available embedding capacity may be determined by the control processor 238 and used to control the combining processor 237. Data items to be queued may be stored temporarily in a data store (not shown) for this purpose.

The data items may include meta data describing the content or providing an indication of an attribute of said information material in which the data is embedded. The meta data may include for example a Unique Material Identifier (UMID), the UMID being given a higher predetermined relative importance than other meta data.

Various modifications may be made to the embodiments herein before described without departing from the scope of the present invention. Although in this example embodiment, the data to be embedded is added to the image in the transform domain, in alternative embodiments the data could be represented in the transform domain, inverse transformed into the spatial domain, and added to the data in the spatial domain.

## CLAIMS

1. An apparatus for embedding data in information material, said data including a plurality of data items, said data items having a different relative importance with respect to each other, said apparatus comprising

an encoding processor operable to encode each of said data items, and

a combining processor operable to combine said encoded data items with said information material, wherein said information material provides a limited data embedding capacity, and each of said data items are encoded and embedded to the effect that a proportion of said limited data embedding capacity is allocated to said encoded data items in accordance with said relative importance.

2. An apparatus as claimed in Claim 1, wherein said encoding processor is operable to encode said data items in accordance with at least one error correction code, said encoded data items including redundant data introduced by said error correction code, wherein said combining processor is operable in combination with said encoding processor to allocate an amount of said limited bandwidth and to generate an amount of said redundant data included in said encoded data items in accordance with said relative importance.

3. An apparatus as claimed in Claim 1, wherein said combining processor is operable to embed said data items in accordance with an application strength, said application strength being applied in proportion with said relative importance of said data items.

4. An apparatus as claimed in Claim 3, wherein said encoding processor is operable to encode said data items in accordance with at least one error correction code, said encoded data items including redundant data introduced by said error correction code, wherein said combining processor is operable in combination with said encoding processor to allocate an amount of said limited bandwidth and to generate an amount of said redundant data included in said encoded data fields and said application strength in accordance with said relative importance.

5. An apparatus as claimed in any of Claims 1 to 4, wherein said encoding processor includes a modulator operable to generate predetermined data sequences and to encode said data items by modulating said predetermined data sequences with data symbols of said data items, and to combine said modulated predetermined data sequences with said information material, wherein said predetermined data sequences are allocated to the effect that a greater amount of spreading of said data items is provided to the more important data items in accordance with said limited data embedding capacity.

6. An apparatus as claimed in Claim 5, wherein said predetermined data sequences are Pseudo-Random Symbol or Bit Sequences.

7. An apparatus as claimed in any preceding Claim, wherein said data items include meta data describing the content or providing an indication of an attribute of said information material in which the data is embedded.

8. An apparatus as claimed in Claim 7, wherein said meta data includes a Unique Material Identifier (UMID), said UMID being given a higher predetermined relative importance than other meta data.

9. An apparatus as claimed in Claim 8, wherein said UMID includes a plurality of data fields each of said fields representing a data item, each of said fields having a different relative importance.

10. An apparatus as claimed in any preceding Claim, wherein said combining processor is operable in combination with said encoding processor not to embed selected data items if said limited capacity has been reached.

11. An apparatus as claimed in any preceding Claim, comprising a control processor operable to receive data indicative of said relative importance of said data items to be embedded and to control said encoding processor and said combining

processor to encode and embed said data items in accordance with said relative importance, and to embed control information in the information material indicative of at least one of the encoding and embedding applied to said data items.

12. An apparatus as claimed in any preceding Claim, wherein said information material is an image.

13. An apparatus for detecting and recovering data embedded in information material using the apparatus claimed in any of Claims 1 to 11, said apparatus comprising

a detection processor operable to detect and to generate a recovered version of said embedded encoded data items from said information material, and

a decoding processor operable to decode and to recover said data items in accordance with the encoding applied to said recovered encoded data items according to the relative importance of said data items.

14. An apparatus as claimed in Claim 13 operable to detect and to recover data embedded in information material using the apparatus claimed in Claim 11, wherein said detection processor is operable to detect and to recover said control information, and in accordance with said control information to decode and to recover said data items.

15. A method of embedding data in information material, said data being a plurality of data items each having a different relative importance, said method comprising

encoding each of said data items,

combining said encoded data items with said information material within a limited data embedding capacity provided by said information material, wherein said encoding and embedding of each of said data items is performed to the effect that a proportion of said limited data embedding capacity is allocated to said data items in accordance with said relative importance.

16. A method as claimed in Claim 15, comprising

receiving data indicative of said relative importance of said data items to be embedded, wherein said encoding and said combining of said data items are performed in accordance with said received relative importance of said data items, and

embedding control information indicative of at least one of the encoding and embedding applied to said data items.

17. A method of detecting and recovering data embedded in information material according to the method claimed in Claim 15, said method comprising

detecting said embedded encoded data from said information material to generate a recovered version of said encoded data, and

decoding said encoded data items to generate a recovered version of said data items in accordance with the encoding applied to said encoded data items according to the relative importance of said data items.

18. A method as claimed in Claim 17, for detecting and recovering data embedded in information material according to the method claimed in Claim 16, comprising

said detecting and recovering said control information, and in accordance with said control information, said decoding said recovered version of said encoded data items to generate said recovered version of said data items being performed according to said control information which is indicative of at least one of the error correction encoding and embedding used to embed said data items.

19. An apparatus for embedding data in information material, said data including a plurality of data items, said apparatus comprising

a combining processor operable to combine said encoded data items with said information material, said information material providing a limited data embedding capacity, and

a control processor operable to select said data items in accordance with an order of relative importance and to control said combining processor to embed said selected data items in said information material within said limited data embedding

capacity, said control processor selecting said data items to the effect that more important data items are embedded before less important data items until said data embedding capacity limit is reached.

20. An apparatus as claimed in Claim 19, wherein said data items include meta data describing the content or providing an indication of an attribute of said information material in which the data is embedded.

21. An apparatus as claimed in Claim 20, wherein said meta data includes a Unique Material Identifier (UMID), said UMID being given a higher predetermined relative importance than other meta data.

22. An apparatus as claimed in any of Claims 19, 20 or 21, wherein said control processor is arranged to queue at least one data item which is not embedded within said limited data embedding capacity until sufficient data embedding capacity within said limit is available, and controls said combining processor to select at least one queued data item and embeds the selected queued data item in said material information.

23. A signal representing information material in which data has been embedded by an apparatus according to any of Claims 1 to 12, and claims19 to 22.

24. A computer program providing computer executable instructions, which when loaded on to a data processor configures said data processor to operate as an apparatus according to any of Claims 1 to 14 and 19 to 22.

25. A computer program having computer executable instructions, which when loaded on to a data processor causes the data processor to perform the method according to any of Claims 15 to 18.

26. A computer program product having a computer readable medium having recorded thereon information signals representative of the computer program claimed in any of Claims 24 or 25.

27. An apparatus for embedding data in information material, as herein before described with reference to the accompanying drawings.

28. A method of embedding data in information material as herein before described with reference to the accompanying drawings.

## ABSTRACT

## DATA DETECTING AND EMBEDDING APPARATUS

An apparatus for embedding data in information material, the data being a plurality of data items each having a different relative importance. The apparatus comprises an encoding processor operable to encode each of said data items, and a combining processor operable to combine said encoded data items with said information material. The information material provides a limited data embedding capacity, as a result for example of the limited bandwidth of the information material itself. Each of the data items are encoded and embedded to the effect that a proportion of the limited data embedding capacity is allocated to the encoded data items in accordance with the relative importance of these data items. As such, for example, an amount of error protection given to each of the data items can be arranged in accordance with the importance of the data items, whilst still satisfying the limited data embedding capacity. Accordingly, a greater amount of protection can be provided to the more important data items, thereby making these items more robust with respect to any processing of the information material and more likely to be recovered correctly.

[Fig 3]

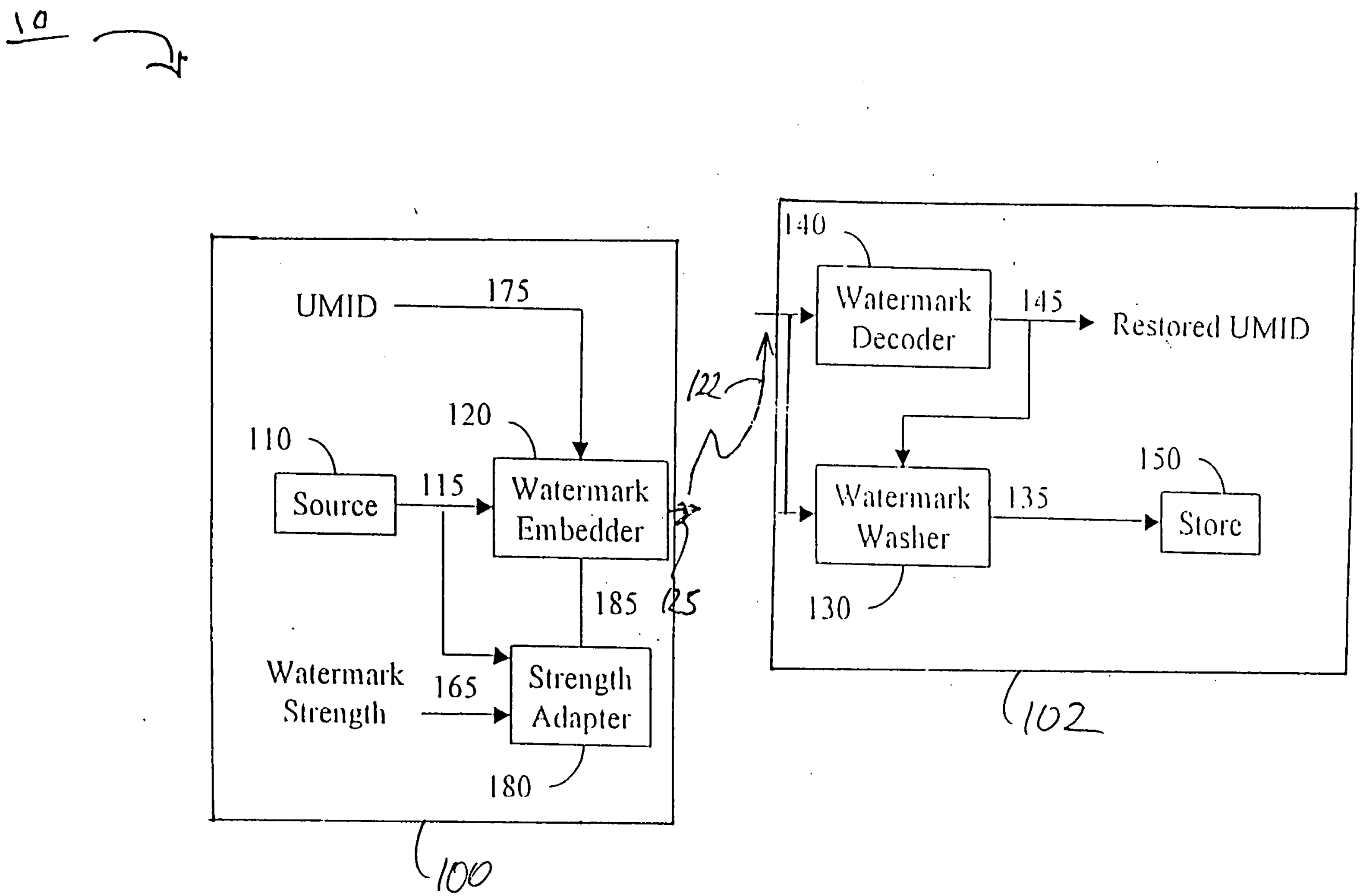

10
UMID
175
110
Source
115
120
Watermark Embedder
185
125
122
Watermark Strength
165
Strength Adapter
180
100
140
Watermark Decoder
145
Restored UMID
Watermark Washer
130
135
150
Store
102

Fig. 1

P/9758 GL

2/7

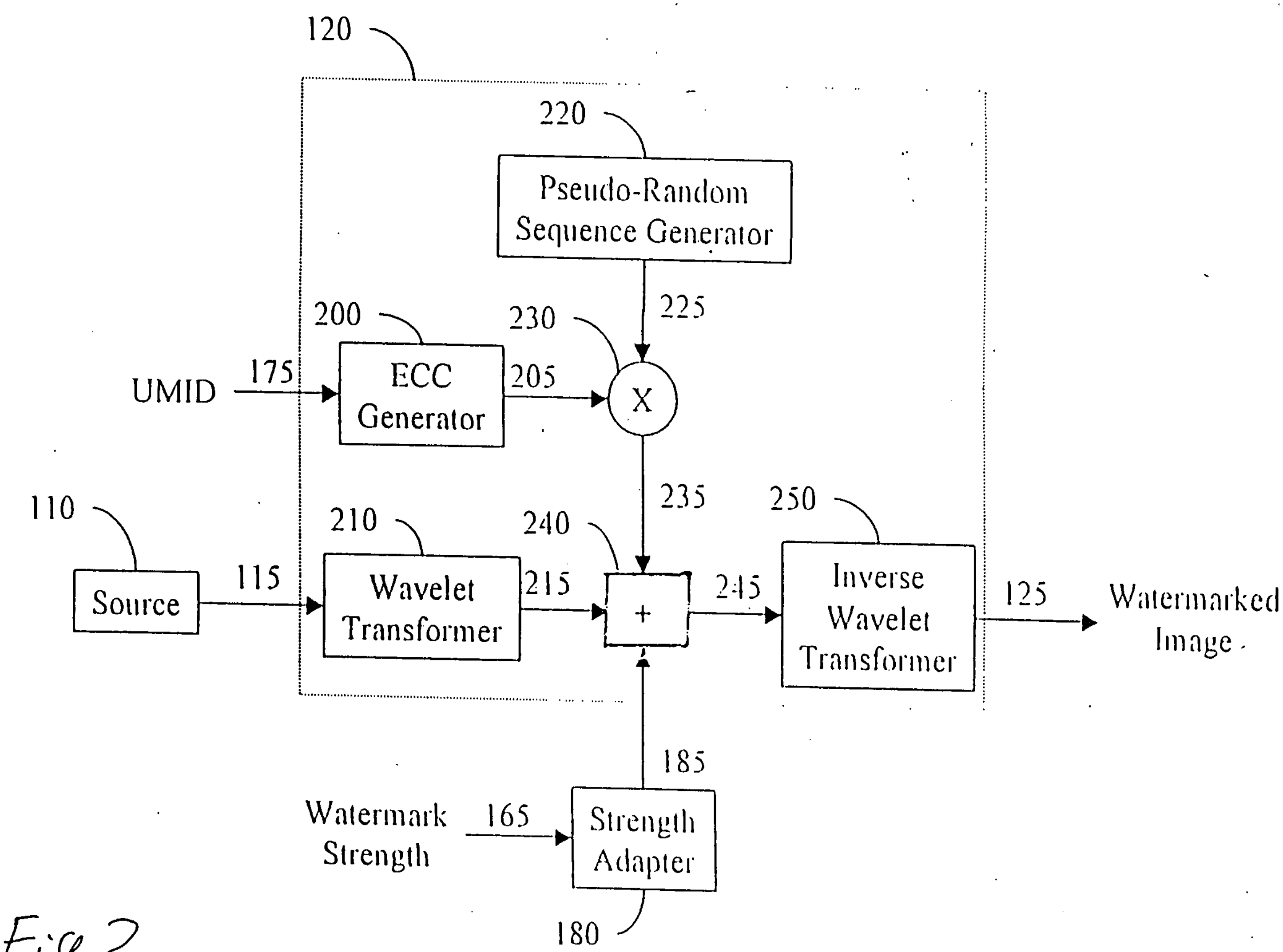
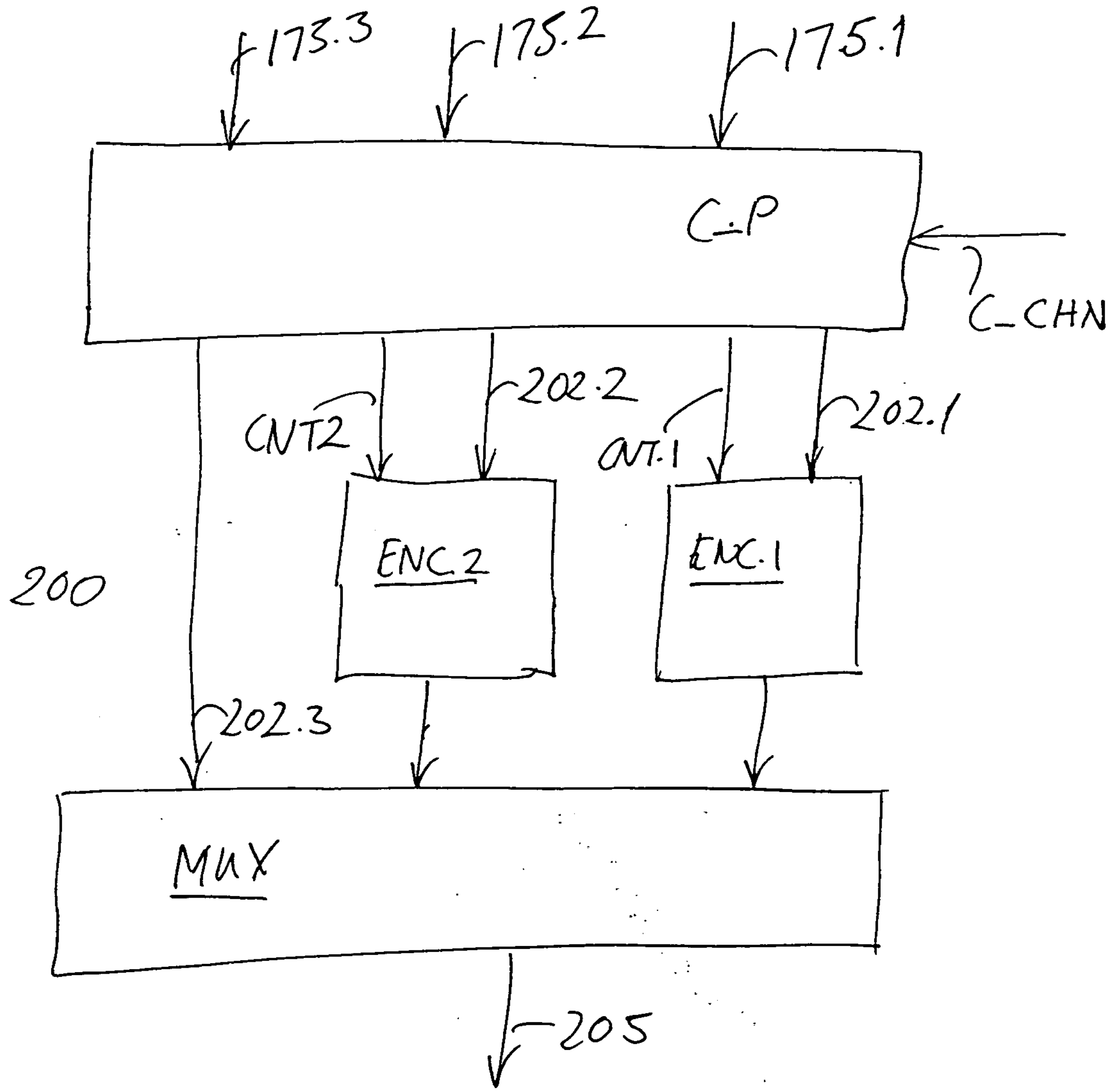



Fig 2

P/9758





175.3
175.2
175.1
C-P
C_CHN
CNT2
202.2
CNT.1
202.1
ENC.2
ENC.1
200
202.3
MUX
205


Fig.3

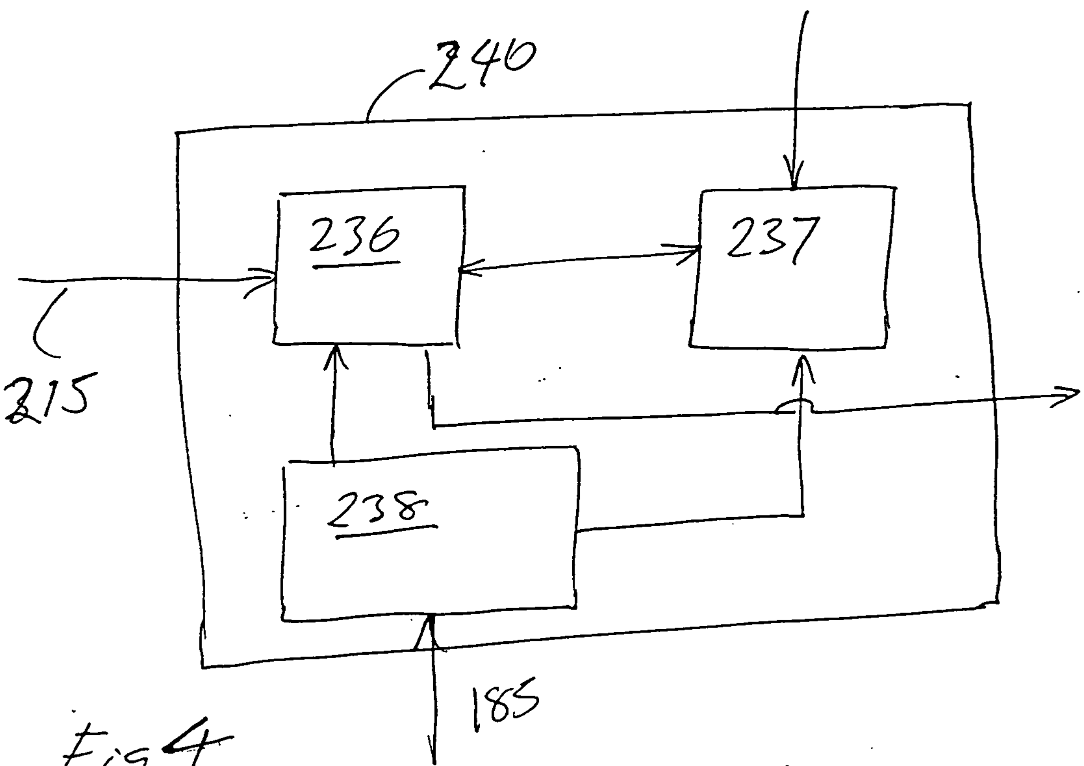



Fig.4

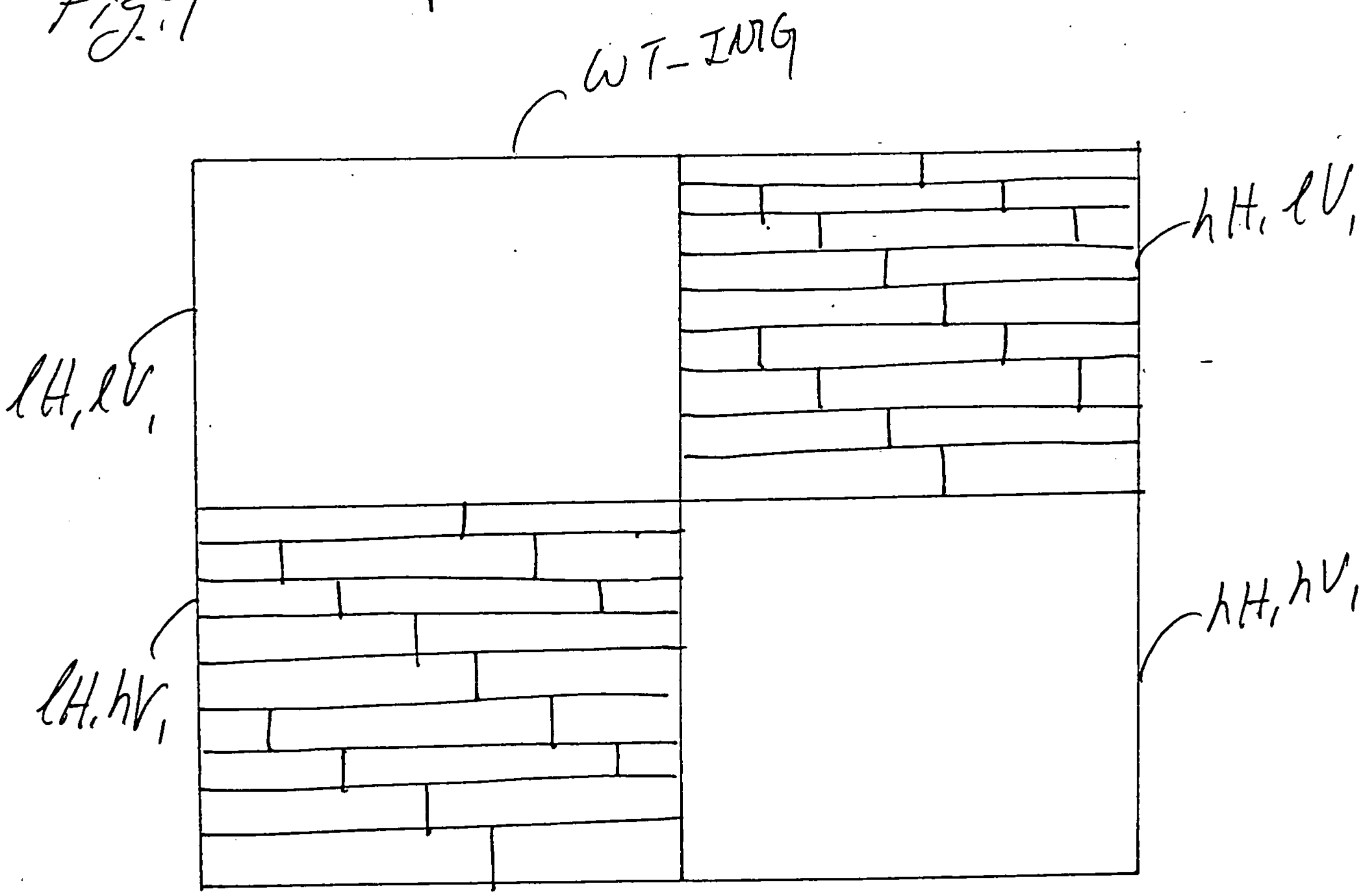



Fig.5

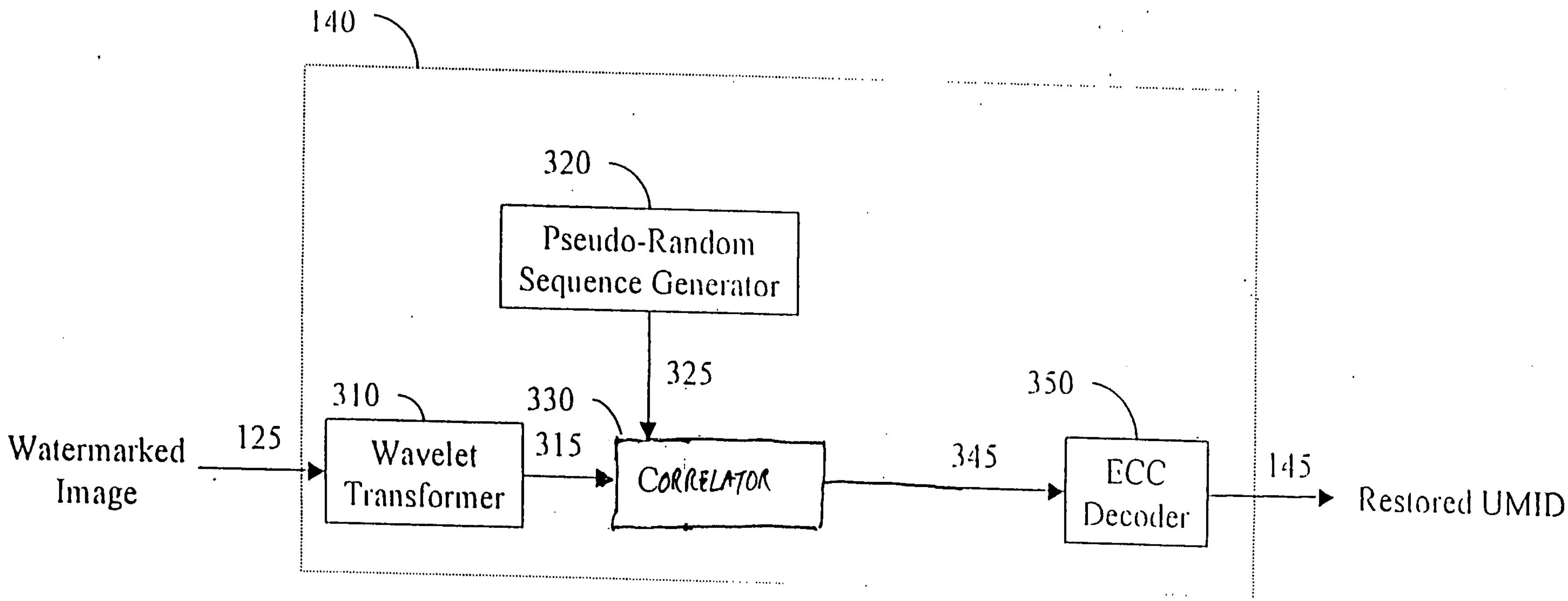

140
320
Pseudo-Random
Sequence Generator
325
310
330
350
Watermarked
Image
125
Wavelet
Transformer
315
CORRELATOR
345
ECC
Decoder
145
Restored UMID

Fig 6

P9758GB



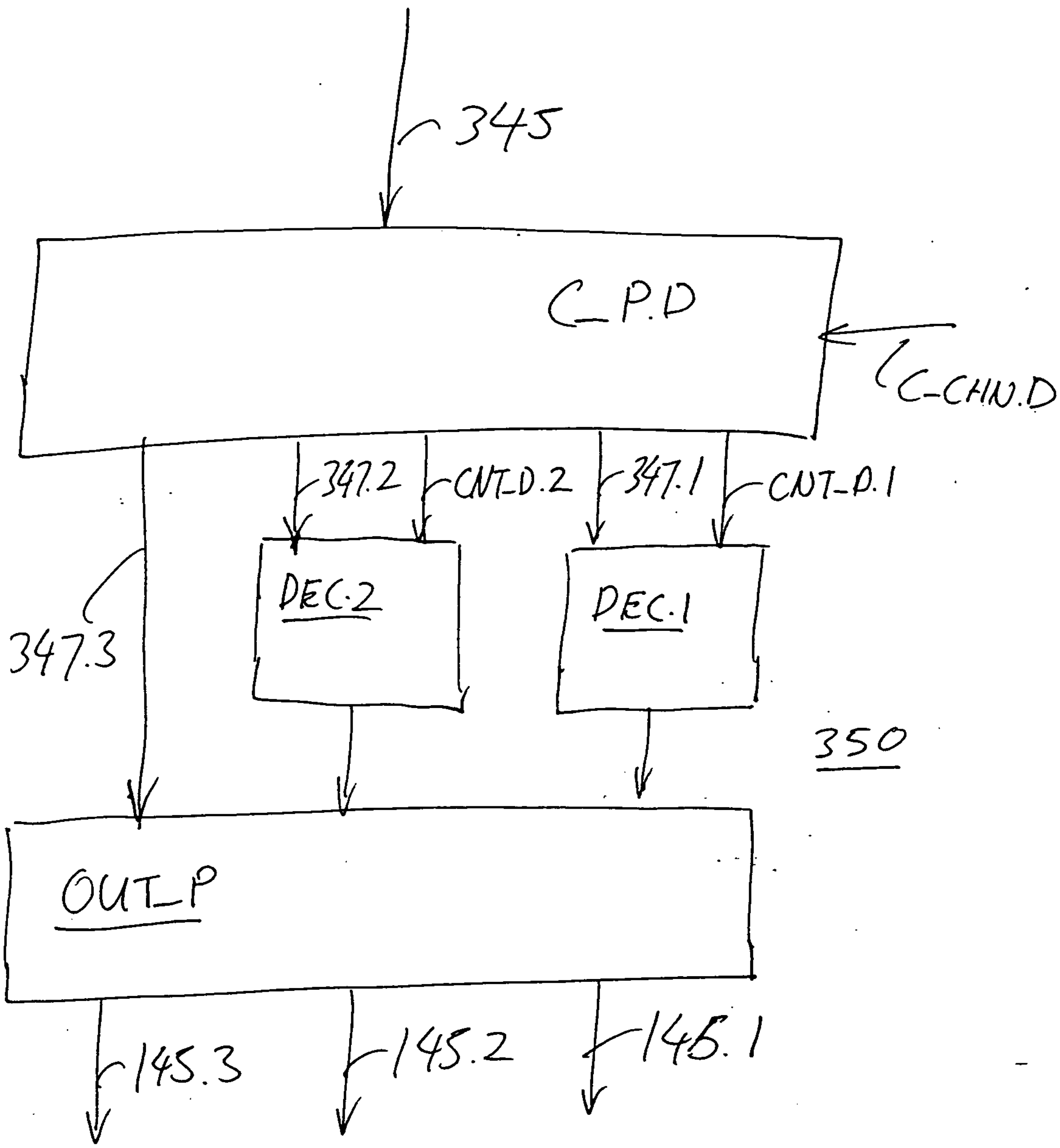



Fig. 7

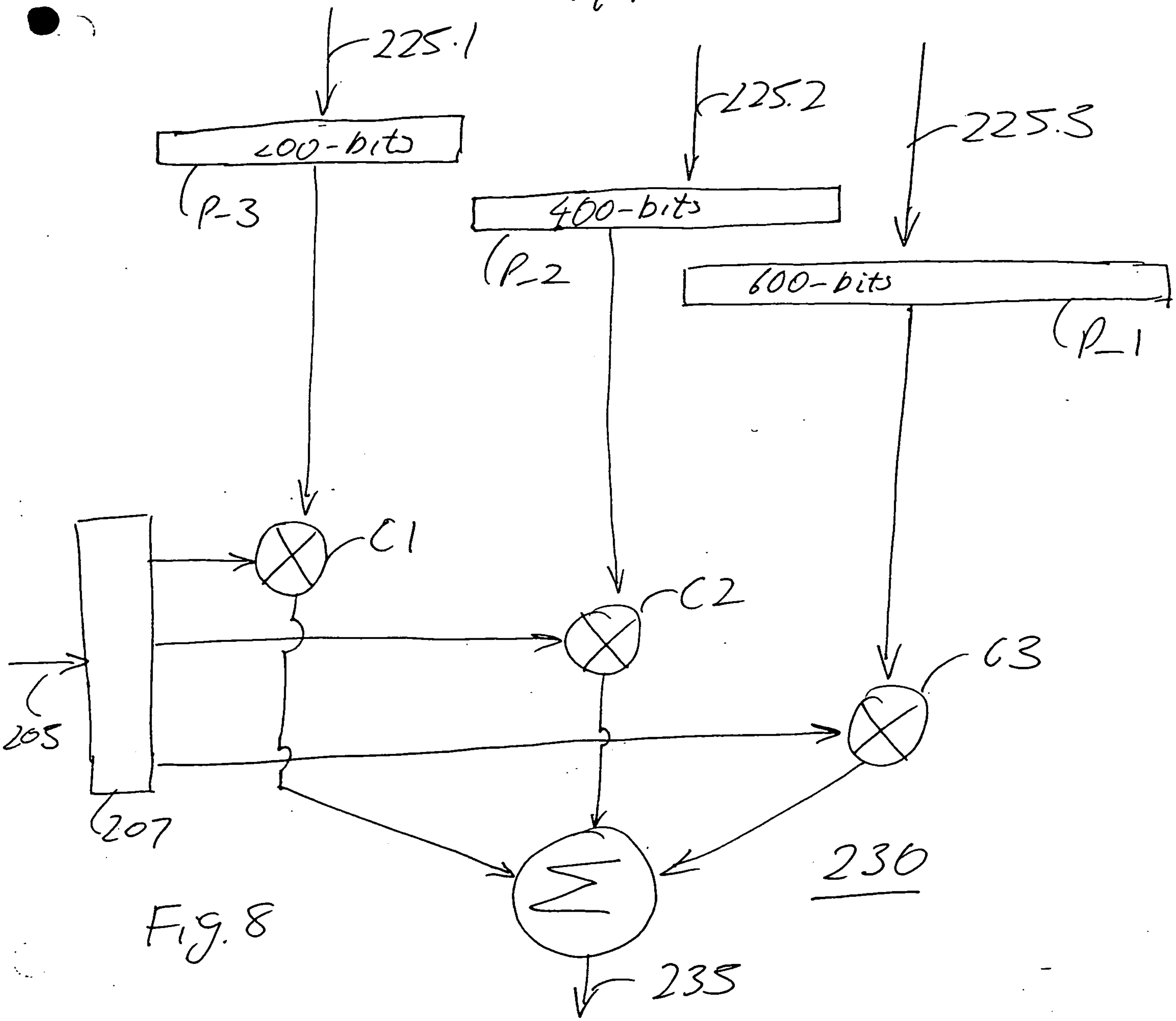

225.1
225.2
225.3
200-bits
400-bits
600-bits
P_3
P_2
P_1
C1
C2
C3
205
207
230
235

Fig. 8

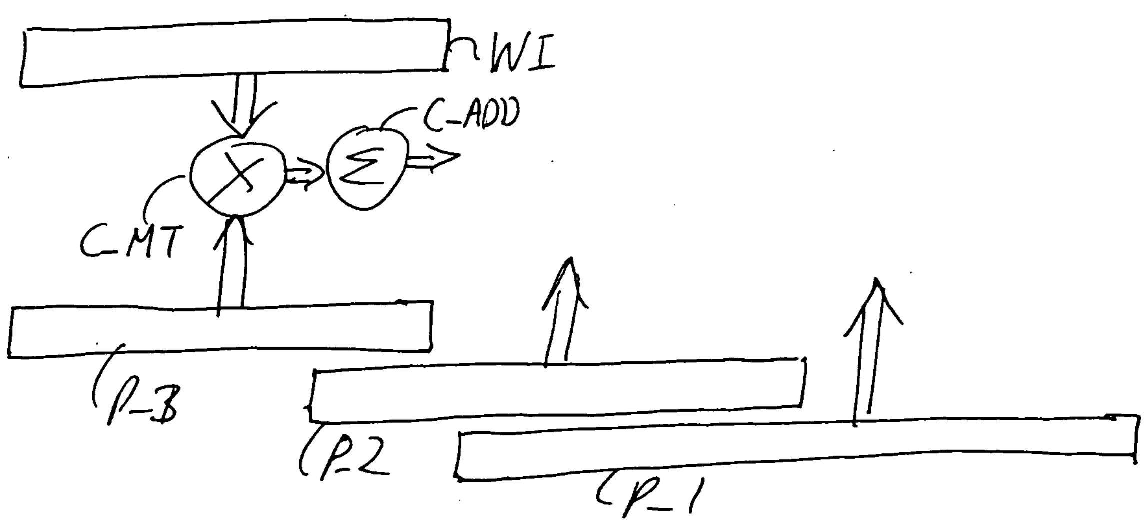

WI
C_ADD
C_MT
P_3
P_2
P_1

Fig. 9